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MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS PECAN BAYOU-COLORADO RIVER BASIN, TEXAS

Public Health Service
Dallas, Texas

July 1961

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MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

PECAN BAYOU

COLORADO RIVER BASIN

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

JULY 1961

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I. INTRODUCTION

Authority

In a letter dated June 8, 1959, the District Engineer, Fort Worth District, Corps of Engineers, asked for the views and recommendations of the Public Health Service on present and prospective needs for a municipal and industrial water supply for Brownwood, Texas. The Public Health Service was also asked to determine the desirability of meeting these needs from the Pecan Bayou project.

This study was made in accordance with the provisions of the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, which establishes a working agreement between the Public Health Service and the Corps of Engineers in regard to the Water Supply Act of 1958.

Purpose and Scope

Projections of future populations, industrial expansion, and water requirements were made for the following municipalities located in the probable "market area" for water impounded in the Pecan Bayou watershed: Abilene, Albany, Anson, Bangs, Breckenridge, Brownwood, Coleman, Cross Plains, Early, Goldthwaite, Merkel, Rising Star, and Santa Anna. Consideration was also given to how the future water requirements of these cities may best be met.

Acknowledgments

The assistance and cooperation of representatives of the following are appreciatively acknowledged:

Bureau of Reclamation, Austin, Texas
Lower Colorado River Authority, Austin, Texas
Central Colorado River Authority, Austin, Texas
Texas Board of Water Engineers, Austin, Texas
Texas State Department of Health, Austin, Texas
West Central Texas Municipal Water District, Abilene, Texas
Brown County Water Improvement District No. 1, Brownwood, Texas
Abilene Chamber of Commerce, Abilene, Texas
Coleman Board of Community Development, Coleman, Texas
Brownwood Chamber of Commerce, Brownwood, Texas
Freese, Nichols and Endress, Consulting Engineers, Fort Worth, Texas
Officials of the cities in the study area.

II. SUMMARY AND CONCLUSIONS

Summary

1. The two reservoirs under study would be located in the Pecan Bayou watershed, just upstream from the existing Lake Brownwood in west-central Texas.

2. The study area boundaries encompass thirteen Texas cities wherein might develop a market for future water that could be stored in the contemplated projects. The study area has been broken into three parts: Subarea 1 centered on Brownwood, Texas; Subarea 2 centered on Abilene, Texas; Subarea 3 centered on Albany, Texas.

3. The major water users in the study area are the following thirteen municipalities: Abilene, Albany, Anson, Bangs, Breckenridge, Brownwood, Coleman, Cross Plains, Early, Goldthwaite, Merkel, Rising Star, and Santa Anna. These cities are the primary sources of wastes in the area. No large water-using industries exist in the area. Waste from oil field operations constitute the major water pollution control problem.

4. The estimated 2010 capability of all existing and firmly planned surface water impoundments plus ground water from the relatively unproductive Trinity Sand aquifer is 58 mgd (million gallons per day).

5. The water quality of the existing and firmly planned sources is either acceptable or can be made acceptable for the general uses of municipal or industrial interests.

Conclusions

1. The municipal population projections for the three subareas in 2010 are as follows: 52,000 in Subarea 1; 220,000 in Subarea 2; and 15,100 in Subarea 3.

2. The totals of the municipal and industrial water requirements in 2010 for each of the subareas are as follows: 9.6 mgd in Subarea 1; 47.2 in Subarea 2; and 2.7 mgd in Subarea 3. In addition to these requirements, approximately 4.6 mgd of stream flows will be required in the year 2010 for the purpose of maintaining water quality objectives in Pecan Bayou which will receive the treated wastes of Brownwood and Early.

3. The projected municipal and industrial water requirements of the entire study area can be met by the existing and firmly planned water supply sources in the area. It is further concluded that the flows required to maintain stream quality objectives in Pecan Bayou can be furnished by these same sources to the year 2010. Therefore, additional storage will not be needed (within the fifty-year projection period) in Pecan Bayou for the purposes of providing additional water supply sources or for providing flows necessary to maintain stream quality objectives.

4. The above conclusions are subject to the condition that future municipal and industrial customers of the Brown County Water Improvement District No. 1 will be able to negotiate with the District for amounts of water in excess of those presently permitted for municipal and industrial purposes. In the event that such negotiations do not produce changes in the amounts of water presently permitted, then additional water supply storage, possibly in the form of the two projects in question, will be needed.

5. At this time, monetary benefits are not expected to accrue due to the provision of any additional storage space in Pecan Bayou for municipal and industrial water supply or preservation of stream quality within the fifty-year economic life of the proposed project.

III. DESCRIPTION OF PROJECT

Location

Pecan Bayou, a tributary of the Colorado River, originates in Callahan County in central Texas. It flows generally southeast 130 miles 1/ from its source to its confluence with the Colorado River near the city of Goldthwaite (see Figure 1). Other major streams in the watershed are Hords Creek and Jim Ned Creek. Hords Creek is a tributary of Jim Ned Creek which in turn flows into Pecan Bayou just above the Brownwood Dam.

The watershed, with an area of 2,202 square miles, has a variance in width from 15 to 30 miles and is approximately 85 miles in length.1/ Portions of the following eight counties are within the watershed's boundaries: Taylor, Callahan, Eastland, Runnells, Coleman, Brown, Comanche, and Mills.

For the purposes of this study, the Pecan Bayou watershed project is assumed to consist of two reservoirs - the Coleman Reservoir and the Pecan Bayou Reservoir. As shown on Figure 1, these proposed dams would be located respectively at river mile 52.2 on Jim Ned Creek and river mile 100.8 on Pecan Bayou. Both of these sites are upstream from the existing Lake Brownwood.

Stream Flow

Most of the flow of Pecan Bayou is surface runoff 1/, with little contribution from ground-water seepage. The U. S. Geological Survey maintains a gaging station on Pecan Bayou one mile north of the city of Brownwood. For a period of 33 years ending in 1958, the average flow of the stream was 165 cfs (cubic feet per second). 2/ It is estimated that there has been no flow in the stream at least 20 per cent of the time during the same 33-year period. It should be noted, however, that these flow conditions reflect the influences of upstream canal diversions and Brownwood Reservoir.

Water Quality

Currently, the concentrations of the chemical constituents in Pecan Bayou water are well within the limits suggested in the Public Health Service Drinking Water Standards - 1946. 3/ Table 1 shows a summary of analyses of biweekly water samples taken from Pecan Bayou at the bridge on U. S. Highway 377 by the Texas State Department of Health as part of their statewide water quality survey.

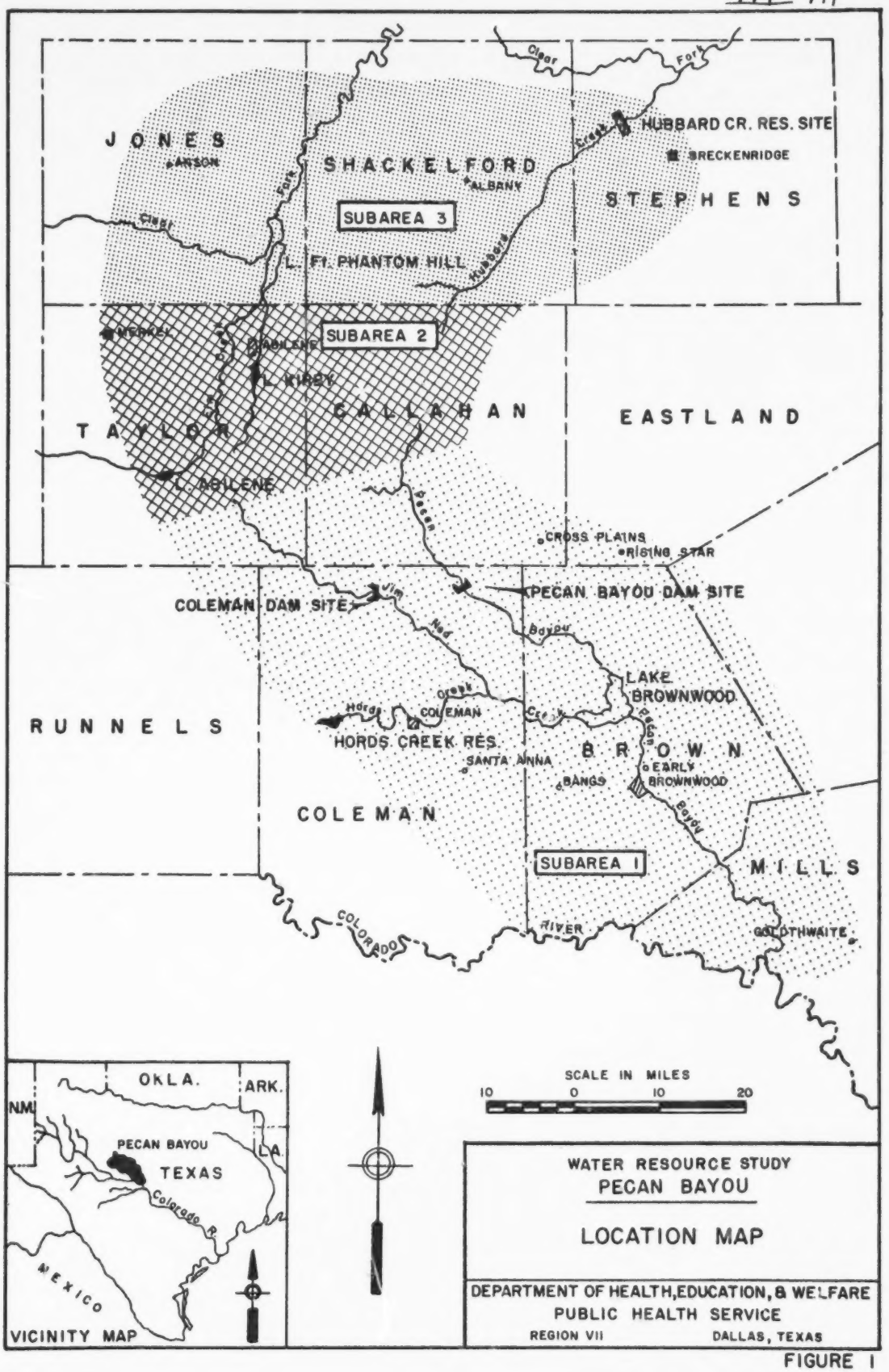

JONES
ANSON
SHACKELFORD
ALBANY
STEPHENS
HUBBARD CR. RES. SITE
BRECKENRIDGE
SUBAREA 3
L. Ft. PHANTOM HILL
Clear Fork
Hubbard Creek
SUBAREA 2
MERKEL
ABILENE
L. KIRBY
CALLAHAN
EASTLAND
TAYLOR
L. ABILENE
Pecan
CROSS PLAINS
RISING STAR
PECAN BAYOU DAM SITE
COLEMAN DAM SITE
Jim Ned Creek
Pecan Bayou
LAKE BROWNWOOD
Hords Creek
COLEMAN
HORDS CREEK RES
SANTA ANNA
BANGS
EARLY
BROWNWOOD
BROWN
RUNNELS
COLEMAN
SUBAREA 1
MILLS
Pecan Bayou
COLORADO RIVER
GOLDTHWAITE
OKLA.
ARK.
N.M.
LA.
PECAN BAYOU
TEXAS
Colorado R.
MEXICO
VICINITY MAP
SCALE IN MILES
10 0 10 20
WATER RESOURCE STUDY
PECAN BAYOU
LOCATION MAP
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 1

Table 1

Water Quality - Pecan Bayou
(Period of Record - 11/12/57 to 3/2/59)
Concentrations in ppm*

	Total Solids	Chlorides	Sulfates
Arith. Average	318	54	36
Maximum	630	140	105
Minimum	171	20	11

*Parts per million

Table 2 shows the results of a more complete chemical analysis of water taken from Lake Brownwood. This analysis was made by the Texas State Department of Health at the request of the Brown County Water Improvement District No. 1.

Table 2

Water Quality - Lake Brownwood
(Sample Taken 1/20/60)

Constituent	Concentration (ppm)
Calcium (Ca)	42
Magnesium (Mg)	9
Iron (Fe)	0.06
Manganese (Mn)	< 0.05
Sodium (Na)	26
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	116
Sulfate (SO_4)	21
Chloride (Cl)	59
Fluoride (F)	0.1
Nitrate (NO_3)	< 0.4
Total Solids	249
Total Hardness as $CaCO_3$	140

The surface water of Pecan Bayou watershed is of satisfactory quality for general municipal and industrial use, after conventional treatment.

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The study area boundaries are shown on Figure 1. These boundaries were determined on the basis of a potential water demand for the water supply potentialities of the project. Some additional territory was included because it would affect the balance of water supply and demand. The study area limits do not coincide with either watershed or county boundaries.

To facilitate the presentation, the general study area has been divided into three subareas as shown on Figure 1. The cities of Bangs, Brownwood, Coleman, Cross Plains, Early, Goldthwaite, Rising Star, and Santa Anna are included in Subarea 1. Abilene and Merkel make up Subarea 2. Albany, Anson, and Breckenridge compose Subarea 3.

Geography

The terrain near Abilene is a rolling plain. The topography changes to become rough and broken toward the south and east, becoming a rolling plain again in the central section. The lower reaches of the study area are again characterized by rather rough, broken relief.

Two major soil regions occur within the study area: The Rolling Plains covering the western portion, and the North Central Prairie blanketing the eastern segment. 4/ The Rolling Plains soil region has sands, loams, and clays which can be utilized in the growing of grain, cotton, and truck crops. The North Central Prairie region is characterized by loams and clays which are suitable for growing the same crops.

The area has a temperate climate with hot summers and cool winters. The mean annual temperature for this region is about 65 degrees and the mean annual precipitation over the area is approximately 25 inches. The average length of the growing season is on the order of 235 days or approximately 65 per cent of the year. 1/

V. ECONOMICS AND POPULATION

Economic Base

General

To determine the probable future economic situation of the study area, an analysis of the raw materials base, population change factors, and locational economic factors has been made, taking into account regional expectations.

Extractive Industries

Mining

The relative importance of mineral extraction to the overall economy varies from county to county. Table 3 shows the value of mineral production for each of the counties for the period 1952 - 1958. The following paragraphs describe the mineral extraction activities in each county.

Brown County has produced principally quarried stone and some petroleum. The limited petroleum production has been from shallow, small fields and recent exploration has not indicated any new fields which might change the present picture.

In Callahan County mineral production consists of oil and natural gas. There were 388,000 bbls. 6/ produced there in 1959 with estimated reserves of 9,089,000 bbls. 6/, which would support production at the present rate until 1982.

Petroleum production in the Glen Cove and Goldsboro fields of Coleman County accounts for a major portion of the value of mineral production there. The estimated reserves of these two fields are 9,623,000 bbls. 6/ which could permit the 1959 rate of production (1,062,000 bbls. 6/) to continue until about 1970. In addition to petroleum, glass sand and other rock minerals are important items in the extractive industry picture of this county.

The mineral production activities of Jones, Shackelford, and Stephens Counties have consisted of petroleum and gas production, limestone quarrying, plus sand and gravel production. 5/

Taylor County produced 1,200,000 bbls. of crude oil in 1958 along with shale, sand and gravel. 5/ This level of oil production is expected to continue for the next ten to twenty years; however, exploration activities are expected to decline.

Table 3 5/

Value of Mineral Production
($1,000's)

County	1952	1953	1954	1955	1956	1957	1958	Seven Year Average
Brown	$ 1,900	$ 2,165	$ 2,537	$ 2,244	$ 2,364	$ 2,401	$ 1,996	$ 2,230
Callahan	1,805	3,224	6,079	9,173	11,362	10,394	8,323	7,194
Coleman	7,256	10,744	10,474	10,395	10,160	12,059	11,188	10,402
Jones	21,712	22,795	23,147	23,537	21,059	21,281	17,300	21,600
Mills	------	------	------	------	------	116	12	64
Shackelford	5,714	6,433	7,533	8,333	8,444	10,652	10,524	8,240
Stephens	11,287	11,919	12,251	9,146	10,963	11,816	10,757	11,200
Taylor	3,793	4,572	5,172	5,587	8,347	11,711	14,067	7,607
Total	$53,467	$61,852	$67,193	$68,415	$72,699	$80,430	$74,167	

Total value of all minerals produced in the eight counties in 1958 showed an increase of approximately 38 per cent over the total of 1952. This increase is significantly greater than the 23 per cent increase for the entire United States for the same period. 5/

Agriculture

As shown in Table 4, the acres of cropland harvested and the value of all crops sold within the eight counties have shown an overall downward trend for the period of record. However, the value of livestock and livestock products sold for the eight counties has been relatively constant, and this activity has become a more important segment of the agricultural economy of the area. The dollar values shown have been adjusted to the common dollar value of 1944 to reflect relative volumes on a comparable base.

Table 4 7,8/

Past Agricultural Activities
Brown, Callahan, Coleman, Jones, Mills,
Shackelford, Stephens, and Taylor Counties

Year	Cropland Harvested (acres)	Value of Crops Sold ($1,000's)	Value of Livestock & Livestock Products Sold ($1,000's)
1959	597,318	n.a.	n.a.
1954	786,909	$ 9,773*	$16,044*
1949	1,054,133	22,096*	15,842
1944	1,002,134	13,362	16,422

*Adjusted to 1944 base

Manufacturing

The city of Abilene, in Taylor County, has been and is the focus for manufacturing in the study area. In 1954, this city had 91 per cent of the manufacturing employees located in Taylor County and 69 per cent of all manufacturing employees within the eight counties considered in this economic analysis. 9,10/ The number of manufacturing employees in Abilene has risen from 1,214 9/ in 1947 to an estimated 3,200 11/ in 1960.

The historical activity of manufacturing, in the seven counties other than Taylor, has been less brisk than that experienced by the city of Abilene and Taylor County.

Table 5 shows data on past manufacturing for all eight counties. The amounts shown for "Value Added" for the years 1954 and 1958 have been adjusted to reflect the change in the value of the dollar since 1947.

Table 5 9,10,12/

Past Manufacturing Activities

County	Employees			Payroll ($1,000's)			Value Added ($1,000's)		
	1947	1954	1958	1947	1954	1958	1947	1954*	1958*
Brown	442	604	1,125	$ 851	$ 1,451	$ 3,664	$1.691	$ 2,130	$ 5,340
Callahan	47	61	---	---	---	---	---	---	---
Coleman	220	224	254	362	558	689	706	750	978
Jones	162	148	---	315	492	---	880	851	---
Mills	---	---	---	---	---	---	---	---	---
Shackelford	---	16	---	---	45	---	---	84	---
Stephens	123	100	---	178	317	---	779	433	---
Taylor	1,294	2,532	3,264	2,251	7,443	10,391	5,068	18,200	23,300
Total	2,288	3,685	4,643	$4,227	$10,306	$14,744	$9,124	$22,448	$29,618

*Adjusted to 1947 base

The number of firms has increased in several categories of manufacturing. Again, it should be noted that Taylor County has accounted for most of the new firms from 1947 to 1954. 9,10/ There was growth in the number of firms producing food, textile mill, leather, lumber and wood, stone, clay, glass, and fabricated metal products. 9,10/

Population

The total populations of Brown and Taylor Counties increased 13 per cent and 315 per cent respectively between 1920 and 1960. However, the other six counties declined in population for the same period.

The populations of all the cities given detailed study showed increases from 1920 to 1960 with the exception of Santa Anna, which lost about 100 people. These city populations have become an increasingly larger segment of the total county populations.

Historical population data pertinent to this study are shown in Table 6. The population considered is that which is, or could be, served feasibly from a municipal water system.

Future Growth

Growth Factors

The study area is enriched with some natural resources for which an increase in demand is expected. The petroleum and natural gas reserves will continue to be utilized at a rate probably not less than the present rate of production. The deposits of brick clay and silica sand hold promise for expansion in the production of bricks, pottery, and glass sand. It is also possible that the fertile soils in the study area can be more fully utilized. However, even with growth and expansion in agricultural activities, the number of agricultural employees will decline due to further mechanization.

Growth and diversification of the manufacturing base will continue - especially in the Abilene area. Resource-based industries are expected to grow - particularly those associated with food processing, stone, clay and glass products, petroleum and natural gas, and possibly chemicals. Also, as the population grows, market-oriented industries such as fabricated metal, machinery, and transportation equipment producers show promise of future development. Trade and service industries will continue to grow as the area develops.

Additional factors contributing to the growth and stability of the study area's economy are the existence of excellent State and Federal highways, several colleges, a major military installation in Dyess Air

Force Base, scheduled airlines at Abilene Airport, and three major railroads - the Burlington, Texas and Pacific, and Santa Fe lines. Also, fuel for heat and power is obtainable in the study area at relatively low costs with oil, natural gas, and some coal present locally.

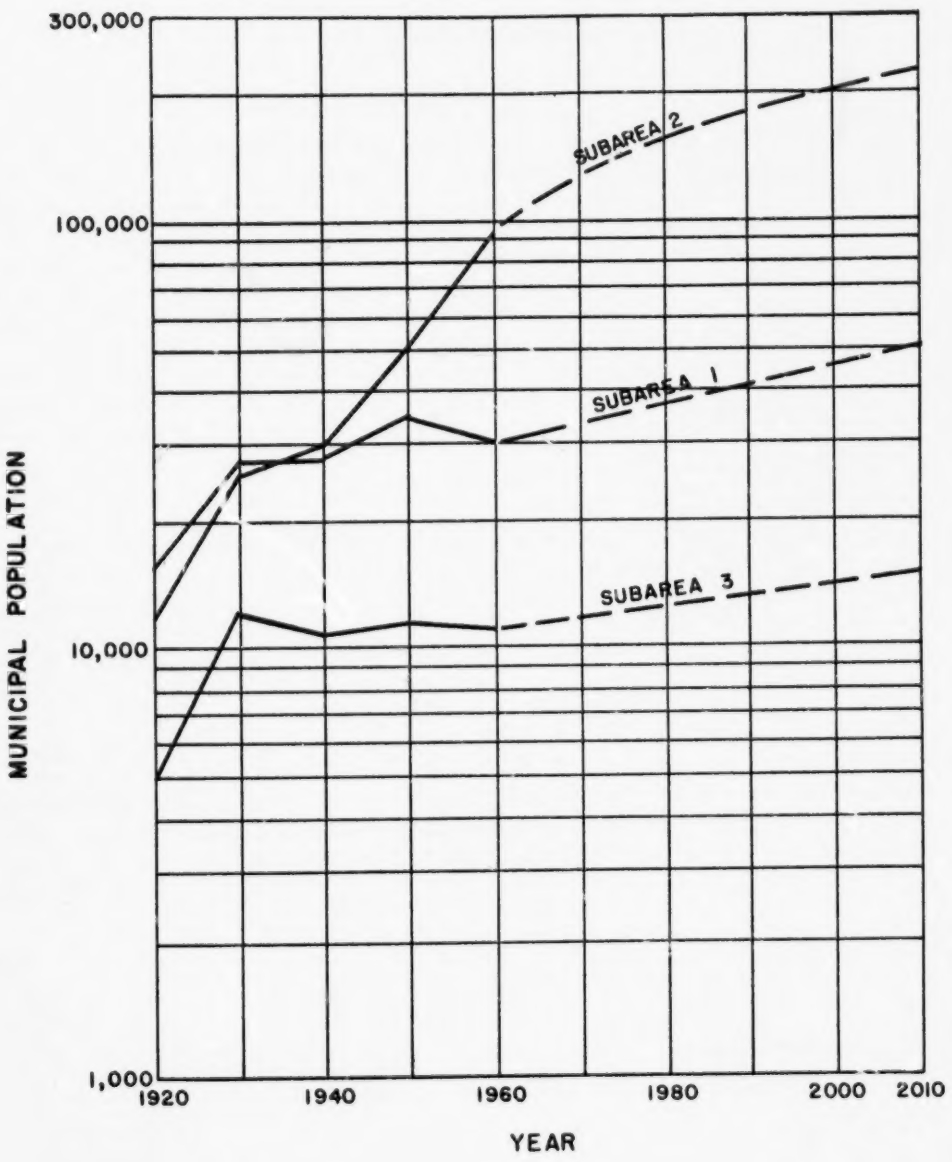
Population Projections

Municipal populations have been projected for each of the three subareas and are shown graphically on Figure 2. In making these projections, consideration was given to published documents, 14,15,16/ historical growth patterns, information obtained in field investigations, and the preceding anlaysis of the economy. Projected populations for the year 2010 are: 52,000 in Subarea 1; 220,000 in Subarea 2; and 15,100 in Subarea 3. These figures represent the combined populations of municipalities within each subarea.

Table 6 13/

Past Populations

Area	1920	1930	1940	1950	1960
Subarea 1					
Bangs	709	717	756	935	983
Brownwood	8,223	12,789	13,398	20,181	16,785
Coleman	2,868	6,078	6,054	6,503	6,298
Cross Plains	700	1,507	1,229	1,305	1,164
Early	---	---	---	625	816
Goldthwaite	1,214	1,324	1,414	1,566	1,365
Rising Star	906	1,160	1,198	1,289	993
Santa Anna	1,407	1,883	1,661	1,605	1,316
Total	16,027	25,458	25,710	34,009	29,720
Subarea 2					
Abilene	10,274	23,175	26,612	45,570	89,428
Merkel	1,810	1,848	2,005	2,338	2,289
Total	12,084	25,023	28,617	47,908	91,717
Subarea 3					
Albany	1,469	2,422	2,230	2,241	2,149
Anson	1,425	2,093	2,338	2,708	2,870
Breckenridge	1,846	7,569	5,826	6,610	6,259
Total	4,740	12,084	10,394	11,559	11,278



WATER RESOURCE STUDY
PECAN BAYOU

POPULATION PROJECTIONS

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 2

VI. WATER REQUIREMENTS

General

Water requirements are separated into two components - municipal and industrial. Municipal water, as defined for the purposes of this report, includes residential, public, and commercial use - plus those industrial uses that are more or less directly related to the population of the municipality. Industrial water is defined as that water use sustained by industries having relatively large demand in comparison to demands of the cities with which they are associated. This use cannot, ordinarily, be related to population through a per capita consumption figure. It is better expressed in terms of gallons per unit of production or per employee, or by direct projection of the expected increase in that industrial activity.

Past Water Use

Table 7 presents the historical water usage of the thirteen municipalities within the study area. The data have been grouped and are presented in terms of water use per subarea. Data for Goldthwaite, Rising Star, and Santa Anna were obtained from records of the Texas State Department of Health. The rest of the data were collected from field investigations.

The historical water use shown in Table 7 has not been separated into municipal and industrial components - except for the city of Abilene. At the present time there are no industrial water users, as previously defined, located within the area under study, except for Dyess Air Force Base located near Abilene which has been considered an industrial water user in this case.

Table 7

1959 Water Use

Subarea	Average Daily Use (mgd) Municipal	Industrial	Appraised Population	Municipal Per Capita Use (gpcd)*
1	4.7	0.0	30,050	168
2	10.0	0.9	85,800	124
3	1.6	0.0	11,270	151

*Includes allowance for treatment plant losses

Existing Sources

Information concerning the yields of the principal sources of water for the thirteen municipalities is presented in Table 8. The firm yields from the surface water sources noted in Table 8 represent quantities available today under present conditions of watershed development.

Table 8

Existing Sources of Water Supply

Subarea	Source	Present Dependable Yield (mgd)
1	Lake Brownwood, Hords Creek Dam, and presently developed ground water of the Trinity sand formation	43.5 16,17,18/
2	Lakes Abilene, Kirby, and Ft. Phantom Hill plus Clear Fork diversion	28.0 19/
3	Lakes McCarty, Arson, and Daniel	1.2 19/

The quality of the water in existing surface supplies of the study area is generally acceptable for use by municipalities and industries. Partial results of chemical analyses of spot samples are shown in Table 9.

The ground water supplies of the area are extremely hard and highly mineralized. Table 9 presents data which give an indication of the ranges in concentration of the various chemical constituents of this water. The quality of the ground water makes very questionable the use of this water for municipal and industrial purposes - except in cases of extreme necessity.

Additional Water Needs

Municipal and Industrial

As the population grows and as industrial expansion takes place, additional quantities of water will be required within the study area. The future municipal and industrial water requirements shown here for the three subdivisions of the study area have been projected after analyses of population growth, municipal per capita water consumption trends, and future industrial production trends.

Subarea 2 is the only portion of the study area where major industrial water use is expected to develop. Industrial development in Subareas 1 and 3 is not expected to bring with it water requirements large enough to be considered industrial water use, as defined herein. Therefore, a separation of water requirements into municipal and industrial components has been made only for Subarea 2.

Table 9 [32/]

Chemical Analyses - Existing Water Sources

City	Date of Sample (mo.-yr.)	Source	Parts Per Million					
			Total Solids	Total Hardness	Magnesium (mg)	Iron (Fe)	Sulfate (SO4)	Chloride (Cl)
Bangs	10-54	Surface	200	113	5	0.03	17	28
Brownwood	1-60	Surface	186	112	5	0.22	14	32
Coleman	5-58	Surface	160	121	8	0.08	12	15
Cross Plains	5-55	Wells	431	298	25	0.15	36	46
Goldthwaite	12-56	Wells	630	373	55	0.25	141	76
Rising Star	11-59	Wells	564	395	37	0.01	34	104
Santa Anna	4-54	Surface	210	135	6	1.1	32	21
Abilene	11-59	Lake Kirby	180	118	8	0.9	16	16
Abilene	11-59	Lk. Ft.Ph. Hill	285	150	15	0.6	30	48
Abilene	11-59	Lake Abilene	255	168	14	0.3	35	34
Albany	2-60	Surface	522	225	15	0.84	24	184
Anson	3-56	Well	1,128	725	67	4.4	41	497
Anson	10-53	Lake	230	140	11	0.68	28	14
Breckenridge	9-59	Lake	160	109	6	0.34	11	17

The future water requirements for the study area are presented in Figure 3 and Table 10.

Table 10

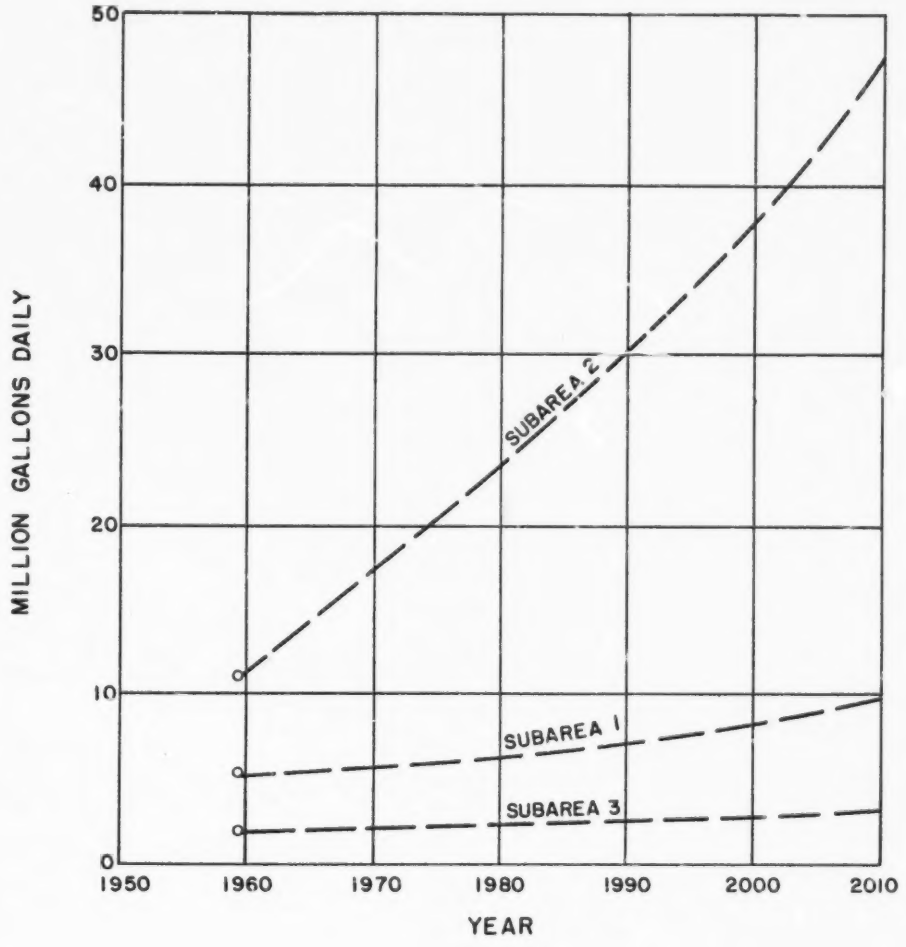
Future Municipal and Industrial Water Requirements - 2010

Subarea	Population	Municipal Use (gpcd)	Average Annual Water Requirement (mgd) Municipal	Industrial
1	55,000	185	9.6	0.0
2	222,800	190	42.2	5.0
3	15,100	180	2.7	0.0

Stream Quality Maintenance

Protection of the quality of Texas waters is primarily the responsibility of State agencies. Stream quality criteria, regulations governing waste discharges, and other pronouncements on the maintenance of water quality within State boundaries come from these agencies. The use of water will almost inevitably result in the production of some liquid wastes which, even after a high degree of treatment, may degrade the quality of the receiving stream. It is essential that consideration be given to the means by which the final disposition of these wastes is effected so that the quality of water in the streams may be kept at reasonable levels.

The thirteen cities involved in this study are presently treating their wastes in various ways. Albany, Anson, and Breckenridge provide primary sedimentation followed by waste stabilization ponds or trickling filters. The effluents from these ponds are discharged to small creeks tributary to the Brazos River. The municipal wastes of Abilene, Coleman, Cross Plains, and Merkel receive secondary treatment, consisting of primary settling, followed by trickling filters and/or waste stabilization ponds. The effluents are used in land irrigation as the final phase of treatment. The effluent from Bangs, after treatment by primary sedimentation and intermittent sand filtration, is discharged into a dry arroyo. Brownwood's existing waste treatment facilities consist of primary sedimentation and trickling filtration. The effluent from Brownwood's facilities is then routed into the main channel of Pecan Bayou. The city of Early provides no community waste treatment facilities, although it is planning a system which will connect with the Brownwood system. Waste treatment facilities at Rising Star consist of an Imhoff tank followed by filtration through contact beds. The effluent discharges to a tributary of the Leon River. The only city, out of the thirteen given detailed study, that does not provide conventional secondary treatment, is Santa Anna. Its existing



WATER RESOURCE STUDY

PECAN BAYOU

PROJECTED MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

FIGURE 3

facilities consist of an overloaded septic tank followed by land irrigation. Goldthwaite has an Imhoff tank followed by a holding pond and land irrigation. Breckenridge has an Imhoff tank followed by a fixed nozzle filter; the effluent enters Gonzales Creek on the Brazos River system. The above factual material concerning existing waste treatment plant facilities was obtained from the Texas State Department of Health. 21/

The treated wastes of Brownwood and Early will probably continue to be discharged into Pecan Bayou. It is estimated that by the year 2010 these highly treated wastes will have to be mixed with stream flows of 4.6 mgd on the average, and 8.2 mgd during critically hot and dry months (from about June through September) in order to maintain stream quality objectives. These flow estimates were made assuming 90 per cent removal of BOD during the waste treatment process.

The cities of Bangs, Rising Star, and Breckenridge are currently discharging their treated wastes into small tributaries of the Colorado and Brazos Rivers. With a continuing effort to improve the quality of the effluent from their treatment plants, no stream quality problems are anticipated from the small quantities of wastes from these cities.

It is assumed that Coleman, Cross Plains, Merkel, and Santa Anna will continue to use land irrigation as the final step in the disposition of their treated wastes. It is evident that with this type of disposal there will probably be no wastes entering the local water courses and therefore no quality deterioration of these waters would occur. However, for this type of treatment to be effective, enough land must be provided for irrigation so that the applied effluent will not simply run off the land into a nearby stream and cause the water quality of the stream to be degraded. The conclusion that the wastes from these cities will not enter the stream is then, of course, based on the added assumption that these sewage farms will be properly designed and operated.

The amounts of treated waste effluents from the waste stabilization ponds at Albany and Anson will be considered as insignificant relative to a possible water quality problem occurring in the Brazos River within the next fifty years. If these ponds are properly operated and maintained, their effluents should not cause any problems related to aesthetics or health.

The largest population center and consequently the greatest source of municipal and industrial wastes in the study area is the city of Abilene. As the city grows, it is probable that the expedient of land irrigation will no longer be entirely adequate for the ultimate disposal of treated wastes. Other measures for the maintenance of satisfactory stream quality below Abilene might be the accomplishment of a higher degree of treatment, by multi-cell lagoons or other methods as yet un-

known. Whatever the solution, it is believed that water will not be transported over the divide from Pecan Bayou to Abilene for use solely as a waste assimilator - unless and until a market develops for re-use of the combined flow for other purposes in the Abilene subarea. It is therefore concluded that the need for water to improve and maintain stream quality in the upper Brazos River tributaries will not constitute a demand on storage reservoirs on Pecan Bayou within the next fifty years.

Plan for Supplying Future Requirements

The plan for supplying the future water needs of the three subareas comprising the study area will be based on the projected requirements for the year 2010 as shown in Table 10 and on the existing and firmly planned sources of water supply shown in Table 11. It should be noted that the firm yields from the surface water sources of Subareas 1 and 2 shown in Table 11 are flows estimated to be available in the year 2010. The quantities shown to be available for Subareas 1 and 2 are less than the firm yields shown in Table 8 (Existing Sources of Water Supply) because of the effect that future physical modification of the watersheds will have on the present patterns of runoff. Estimates for 2010 firm yields in Subarea 3 are not available so these figures are identical with those in Table 8.

Table 11

Sources of Water Supply in 2010

Subarea	Source	Quantity Available (mgd)
1	Lake Brownwood, Hords Creek Dam Dam, and presently developed ground water of the Trinity sand formation	24.9 [18,22,23]
2	Lakes Abilene, Kirby, and Ft. Phantom Hill plus Clear Fork diversion	32.3 [22]
3	Lakes McCarty, Anson, and Daniel	1.2 [19]
	Total	58.4

In 1927 the Texas Board of Water Engineers issued the Brown County Water Improvement District No. 1 permits which allowed them to divert from Pecan Bayou 50,590 A-F/yr (acre-feet per year) for irrigation use and 16,800 A-F/yr for municipal and industrial use. The total amount that may be diverted is essentially equal to the estimated present-day firm yield of Lake Brownwood, which is owned by the District.

Articles 7471 through 7472d of Vernon's Civil Statutes 24/, passed in 1931, are not retroactive and do not cause forfeiture of the District's prerogative to initiate any changes in the permitted amounts noted above. In order that the water from Lake Brownwood be used for municipal and industrial purposes, in amounts greater than presently allocated for those purposes, future customers of the District would have to request the District to initiate changing the present permits. If the District did not desire to make these changes, then these future customers could not utilize Lake Brownwood water to the extent shown in Table 11 and would be forced to negotiate for additional water supply storage elsewhere. In this event, the artificially created shortage might possibly be met from the contemplated upstream Federal project (s).

The quantity of water available to Subarea 1 in 2010 is an estimate based on the assumptions that no project would be built in the Pecan Bayou watershed and that the yield from ground water sources in the area would be the same in 2010 as it is now. Additional development of the ground water in the Trinity sands (at present a source of water for Cross Plains, Goldthwaite, and Rising Star) is questionable. This ground water has both a relatively high mineral content and a high total hardness. From information obtained in the field investigation, it was concluded that the capability of this aquifer to furnish water through existing facilities would probably not increase. The quality of the water used in Subarea 1 has been discussed previously, and it was concluded that it is acceptable for municipal and industrial uses.

It should again be noted that the firm yields of Lakes Abilene, Kirby, and Ft. Phantom Hill plus the Clear Fork diversion estimated for the year 2010 are less than the yields estimated to be presently available. The quality characteristics of the water from these three lakes have been presented earlier in the report.

For the purposes of this report, the water supplies of Subareas 2 and 3 will be integrated and compared to the combined future water requirements of these two subareas. This is necessary because Hubbard Creek Reservoir will be a supply source for both of these subareas. This particular dam is being constructed by the West Central Municipal Water District of which Abilene, Albany, Anson, and Breckenridge are member cities.

Hubbard Creek Reservoir will be located near the city of Breckenridge on Hubbard Creek in Stephens County, Texas. It has been estimated 22/ that the firm yield from this lake in the year 2010 will be approximately 15.5 mgd. The firm yield of Hubbard Creek Reservoir under present conditions is approximately 30.0 mgd. 19/ Table 12 shows a summary of data which indicates that the water of Hubbard Creek has concentrations of chemical constituents which are low enough to make the water suitable for municipal and industrial purposes.

Table 12 25/

Water Quality
Hubbard Creek Near Breckenridge, Texas
(Period of Record - 4/15/55 to 9/30/55)

Item	Weighted Average Concentration (ppm)
Silica	11
Calcium	37
Magnesium	3.7
Sodium)	25
Potassium)	
Bicarbonate	109
Sulfate	95
Chloride	41
Fluoride	0.4
Dissolved Solids	192
Total Hardness as $CaCO_3$	108

As noted earlier, it is estimated that Lakes Anson, Daniel, and McCarty, which are present water supplies located in Subarea 3, have a firm yield of about 1.2 mgd. Also, in previous discussion it was determined that the quality of the water from these sources can be brought to a level so as to make the water acceptable for municipal and industrial uses.

It may be concluded from a consideration of the estimated 2010 firm yields and quality of the existing water supply sources in Subarea 1, that these sources with a combined yield of 24.9 mgd will be able to satisfy the future municipal and industrial water requirements that have been projected for this area.

It is also concluded that the future municipal and industrial water requirements of Subareas 2 and 3 should be met, insofar as possible, from Lakes Abilene, Kirby, Ft. Phantom Hill, the Clear Fork diversion, and the new Hubbard Creek Reservoir. At such time as these sources of water supply become unable to meet the demands placed upon them, it is assumed that these supplies will be supplemented by water from the existing Lake Brownwood on Pecan Bayou. With Lake Brownwood as a supplemental source of water supply to Subareas 2 and 3, it is concluded that the future water requirements of these areas can be met through the year 2010.

In the overall picture of the supply and demand balance of the entire study area, it can be seen that the total projected municipal and industrial requirements of 59.6 mgd exceed the figure of 58.4 mgd, estimated to be the total amount of water available, by some 1.2 mgd.

This slight discrepancy amounts to two per cent of the projected requirements and lies well within the accuracy of such a projection made for rifty years in the future. Therefore, it is concluded that additional storage need not be provided in Pecan Bayou for the purpose of satisfying future municipal and industrial water requirements.

Earlier in this report, it was estimated that by the year 2010 the treated wastes from Brownwood and Early will have to be mixed with approximately 4.6 mgd of stream flow in order to maintain stream quality objectives in Pecan Bayou. Based on the previous conclusion that the municipal and industrial water requirements in the year 2010 can be met by the full utilization of all the existing and firmly planned water supply sources within the area, it might be further concluded that in the same year additional storage to provide 4.6 mgd would be needed to maintain Pecan Bayou's water quality in the absence of a higher degree of treatment.

Analysis has shown that additional storage to provide 4.6 mgd for water quality maintenance will not be needed until about the year 2010. Because of the limitations in accuracy of the fifty-year projections made as part of this analysis, it is concluded that the construction of additional storage space within Pecan Bayou is not warranted for the purpose of providing flows to maintain stream quality. Studies made in the future may show a more definite need for additional storage, but it is not possible at this time to conclude, without doubt, that more storage for this purpose is needed.

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